FATHER E. GHERZI, S. J., ON A STUDY OF THE RAINFALL OF CHINA[1]

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By ALFRED J. HENRY

Father Gherzi's work is in two parts and an atlas of charts. Part I contains summaries of the available statistical matter and the discussion and Part II contains the observations from 198 stations for each month and the year. The atlas contains 34 charts of monthly seasonal and annual values on maps 11½ by 17⅜ inches. (29.2 x 44.2 cm.)

I quote the following from Father Gherzi's foreword to Part I:

The work here presented to the public can not be considered as definitive. The number of stations[2] is too limited to furnish for a region so vast as China results that are both general and detailed.

It is necessary, first of all, to justify this attempt at generalization of the distribution of precipitation over China knowing that it is based on data that are relative incomplete.

In 1911 Father L. Froc published a research on the rainfall in China during a period of 11 years (*La pluie en Chine, d'après une periode de 11 années.* Changhai) and at the same time expressed his entertainment of hope for a more complete publication on the same subject.

At that time, when young China seemed willing to enter the path of scientific research through reorganization of government, it was hoped that in 10 or 15 years the number of meteorological stations, maintained by the Government or otherwise, could be increased tenfold and, with the network of the stations of the customs service, could thus furnish very complete data for an exhaustive study of rainfall in China.

Events since 1911 and present serious conditions have removed that flattering hope to the far distant future. It is for that reason and in order not to delay too long the publication of data that will be very useful to numerous public services that the work is now presented.

Despite the fact that there are regions for which there are no data it is believed that the charts will be truly useful, and will furnish for some regions information that is important and even definitive.

The network of the stations of the customs service while much less close than that of certain conservancies, such as the Chihli River Commission, is much older. The data extend over several decades and there is uniformity in instruments, which partially compensates distribution over extensive regions. These data permit one to trace with assurance the principal curves on the charts accompanying the tables.

The stations of the conservancies[3] are more recent. We have omitted publication where the record is for only one year, but have made use of the values in drawing certain isohyets in regions of our charts where no stations are entered.

The stations of the Chihli River Commission although more recent than the majority of the stations of the customs service form a well equipped network, so close that it has been considered proper to detail the results in a series of special charts. We could not attempt such work for other interesting regions, for example that under the Yangtse River Commission.

The purpose in view has been to give a general survey of the distribution of precipitation and days with precipitation over China based especially on the long series of observations at stations of the customs service. This appears to have been attained rather well.

We have used a larger number of curves than is usual in such researches; this seemed useful in order to give a graphic representation of what may be called the "precipitation gradient" (*gradient pluviométrique*) for the different months of the year. This gradient is related to important facts: Torrential rains in certain regions, sudden rises in large rivers and their tributaries, and floods. In addition the gradient indicates the regions more interesting for detailed study with a view to the construction of dams or levees.

The utilization of these rainfall details would require observations on relative humidity, temperature, evaporation, and nature of the terrain, which we have not been able to obtain. The curves will, at least, indicate where it would be most advantageous to establish stations for the study of these elements.

The statistical data given in Part II of the work are used in the following manner. The method of consideration employed by Father Froc appeared very interesting and also contributed information such as is desired by the engineers who will use this work, so for those reasons we have retained it, using the more extended series of observations.

It is obvious that certain values and certain conclusions will be different from those based on the series of observations extending over the period of 11 years to which the former study was limited. There have been added to the tables analysis of charts, data on storms, snow and hail at different stations, and also a discussion of the causes of rainfall and rainfall periodicity in China.

In the matter of the location of the rain gauges it appears sufficient to give the approximate latitude and longitude of the station with the details previously published by Father Froc. There has been frequent discussion as to the best exposure for a rain gauge, in regard to removal from neighboring objects and height of the receiver. It can not be stated that all of the instruments whose records have been used are exposed under the best possible conditions. No; it can be stated, however, that at all times and in all places there has been an attempt to attain the ideal.

It is well to state that the instruments in use are of two types: The 8-inch gauge (Negretti-Zambra evidently this is the type known as the "Meteorological Office" rain gauge with 8-inch diameter and graduated glass measure of one-half inch capacity) placed near the ground (equipment at stations in the Customs Service) and that sometimes called the Zi-ka-wei gauge in the conservancies—the model adopted for field in the United States and in the Philippine Islands, and which appears to be very advantageous in places where it is difficult to obtain measuring glasses, as at the present in the provinces of China.

Unfortunately, in all of the vast region of China there are only three places where recording rain gauges are in operation: Hong Kong, Tsingtao, and Zi-ka-wei.[4]

In this connection it will be noted, to our great regret, that in the list of rainfall stations there are missing stations strictly Chinese that is, stations at universities and schools. Although the installation of a rain gauge is a simple matter, it must be acknowledged that the patience to observe and record is still lacking in those who would find interest in meteorology. We regret that the 1,500 stations which the director of the *Observatoire Central de Péking* promised immediately are not organized.

OBSERVATIONAL MATERIAL

Father Gherzi divides his observational material into two groups, one of fundamental stations of which there are 60, and another of secondary stations to the number of 109. The fundamental stations are those maintained by the customs service of China and extend back in a few cases to the early eighties; the observations at most of the customs service stations are continuous. The mean monthly, seasonal, and annual values are given for both groups of stations. I have computed from the fundamental stations the mean monthly, seasonal, and annual precipitation for China as a single geographic unit, and give the values (in millimeters) for what they are worth in the paragraph below. The fractions of a millimeter have been rounded off.

January	28	August	164
February	45	September	119
March	66	October	65
April	100	November	40
May	122	December	28
June	173		
July	169	Annual	1, 119

The secondary stations furnish results from 109 places in China variously distributed throughout the provinces. The observations at these stations are due to the efforts of various boards and commissions and to religious organizations, mostly of the Roman Catholic Church. Nearly all the records at the secondary stations are recent and for but a few years. The continuity of the records is not of the best.

[1] Etude sur la pluie en Chine, Changhai, 1928.
[2] Including stations recently established in the valley of the Hwai, the number is 240.
[3] The Yangtse River Commission and, especially, the Hwai River Board.
[4] The gauge installed at Peking has furnished some interrupted records.

THE CAUSES OF RAINFALL IN CHINA

Father Gherzi considers the two great causes of precipitation in China to be the movements of extratropical and tropical cyclones, or typhoons as they are called in that part of the world, and the régime of the two monsoons, the winter, and summer monsoons of eastern Asia.

The number of barometric depressions that form in west and central China is relatively great. The total number for 25 years corresponding to the several paths followed by them is given in the following table. The author distinguishes seven paths, the last being the most northern one for which complete data are not available. Storms following this path descend from Siberia and curve to the east and northeast over the Liaotung peninsula. Table No. 1 follows; path No. 1 is in the south.

TABLE No. 1.—*Number of extratropical cyclones which have traversed the different paths in central and east China (last 25 years)*

Path	January	February	March	April	May	June	July	August	September	October	November	December	Annual
No. 1	10	13	**18**	12	11	4	1	1	1	2	2	7	82
No. 2	**17**	12	14	10	9	7	2	4	1	5	3	4	88
No. 3	**21**	19	21	19	14	9	1	1	4	4	6	8	127
No. 4	13	5	15	**18**	14	15	2	4	4	7	8	10	113
No. 5	**14**	11	**21**	**26**	**24**	**26**	8	3	4	10	16	17	180
No. 6	**20**	10	18	19	16	12	8	3	4	6	11	12	139
Average	3.8	2.8	4.3	4.1	3.5	2.9	0.9	0.6	0.7	1.4	1.8	2.3	29.1

I present in Figure 1 the mean paths of extratropical and tropical cyclones which influence the rainfall of China. The base map used shows also the Provinces into which China is divided. I am indebted to Dr. O. E. Baker of Clark University and the United States Department of Agriculture for this map. It is not possible to show the place of origin of the tropical cyclones that strike the China coast, but it may be said that they can be traced back over the Pacific far beyond the one hundred and forty-fifth meridian east of Greenwich and close to but probably a little south of the tenth parallel of north latitude.

From the figures of Table 1 it may be seen that the average number of extratropical cyclones traversing central and eastern China is 29 per annum and that the months of greatest frequency are March and April. If a correction be applied to these averages on account of the unequal length of the months, the greatest frequency will still be in those months.

It may be remembered that the great Siberian anticyclone of winter has practically disappeared by the end of March and that a transition to lower pressure over all of central and eastern China is now taking place. Doubtless the increase both in the number of extratropical cyclones or continental depressions and the precipitation is more or less directly related to the changing pressure distribution of the spring season over central China.

It is rather difficult to evaluate the influence of extratropical cyclones on the precipitation of China. Father Gherzi prefers to call them "continental depressions or extratropicals," evidently to emphasize the fact that a cyclonic circulation is not always present and even when present is mostly weak, although at times strong circulations and steep gradients develop especially when the extratropical cyclone reaches the coast.

An examination of the daily weather charts for China and the Far East clearly reveals the predominant influence of the great winter anticyclone of Siberia which often overspreads China and equatorward to the Tongking Gulf. This fact alone is sufficient explanation of the absence of vigorous cyclonic storms in China in the cold season and the sparse rainfall of northern China.

Weather Bureau Bulletin A[1] based on 10 years observations shows that the chief path of extratropical storms around the North Pole starts about the southern tip of Japan in north latitude 30°, passes thence northeastward crossing the Pacific almost parallel with the fifty-second degree of north latitude, continuing thence across the continent of North America close to the forty-eighth parallel of north latitude to the North Atlantic about the fiftieth meridian of west longitude where it bifurcates the greater number of the storms, takes a more northerly course crossing Iceland and again dividing a portion disappearing west of Nova Zembla and the larger portion in the neighborhood of the Urals in eastern Russia. The southern branch from the Atlantic passes into Europe over France, skirts the Mediterranean, and the storms mostly disappear about the Black Sea. Thus there is a hiatus in the path of these storms in their course around the globe. The distance between the eastern termini and the Pacific track is about 90° or a quarter of the circumference of the globe. This summary also shows that May is the one month of the year in which at least one or more extratropical cyclones can be plotted in each 10° square around the globe with the exception of that one between 50° and 60° north latitude and 130° to 140° east longitude, the region of mountains in northeast Siberia facing the sea of Okhotsk.

Fully developed extratropical storms rarely cross the Urals although the free-air portion of the storm may survive and again reach contact with the surface farther eastward and southward as happens at times in the United States. Even those storms that move southeastward via the valleys of the Ob and Yenisei are mostly in a dying condition and seldom pass as far inland as Lake Baikal. The few exceptional storms that survive and pass southeastward from Baikal over Mongolia to the plains of north and central China recurve to the northeast as illustrated in Figure 1 by the unnumbered path at the top.

In the cold season any development of a depression over China is almost immediately followed by a fresh incursion of cold northerly winds from Siberia, hence the small precipitation in north China of that season. In the warm season when pressure over China is relatively low vertical convection becomes active and heavy showers fall at times.

The order of the paths as given in Table 1 is from south to north as can be seen from Figure 1 and it will be noticed that the origin of path No. 4 is identical with that of No. 5, storms following the last named track having more of a northerly component than those of path No. 4.

The origin of extratropical cyclones in central and east China as given by the author is considered as indicating his belief that the points so indicated represent the true origin of the storms so far only as present observations are concerned; it should be remembered that the absence of meteorological observations to the westward precludes the possibility of determining the exact place of origin, moreover, most if not all of these extratropical cyclones may be secondaries that develop from a primary that is passing eastward in latitudes north of the present field of observation.

[1] Summary of International Meteorological Observations by H. H. C. Dunwoody, Washington, D. C., 1893.

TYPHOONS

Typhoons contribute largely to the rainfall of China. The distribution of typhoon rainfall varies with the month of the year and according as the typhoon continues to move toward the northeast or fills up in place.

The dashed lines—typhoon paths—in Figure 1, show the points on the Chinese coast where typhoons on the average, most frequently strike. The table below gives in addition the number of typhoons in 31 years that reached the land or traversed the various Provinces in the south and east of China.

The figures of the above table show quite clearly that the main onset of the typhoons begins with July in the Province of Kwantung and continues throughout August and September, also that the peak of the monsoon season is reached successively later on the coast of China north of Kwantung. The number of typhoons in a season also diminishes with increase in latitude.

Seasonal rainfall distribution.—Winter is clearly the time of least precipitation of the year especially to the north of the Yangste and December is the month of least precipitation in the majority of provinces. At this time

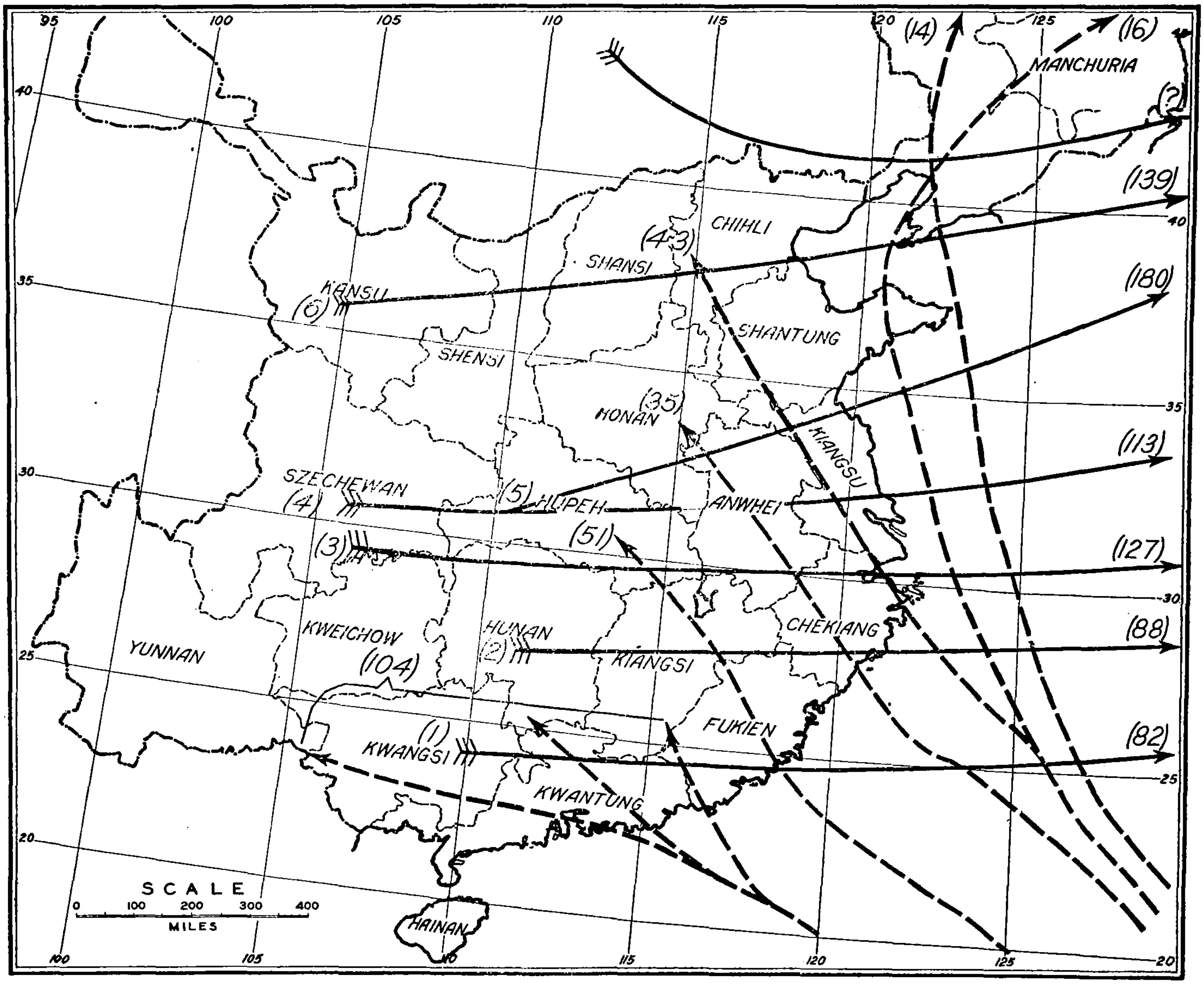


FIGURE 1.—Distribution and tracks of continental depressions (full lines) and monsoons (dashed lines) that traverse China. (After Fr. Gherzi, S. J.)

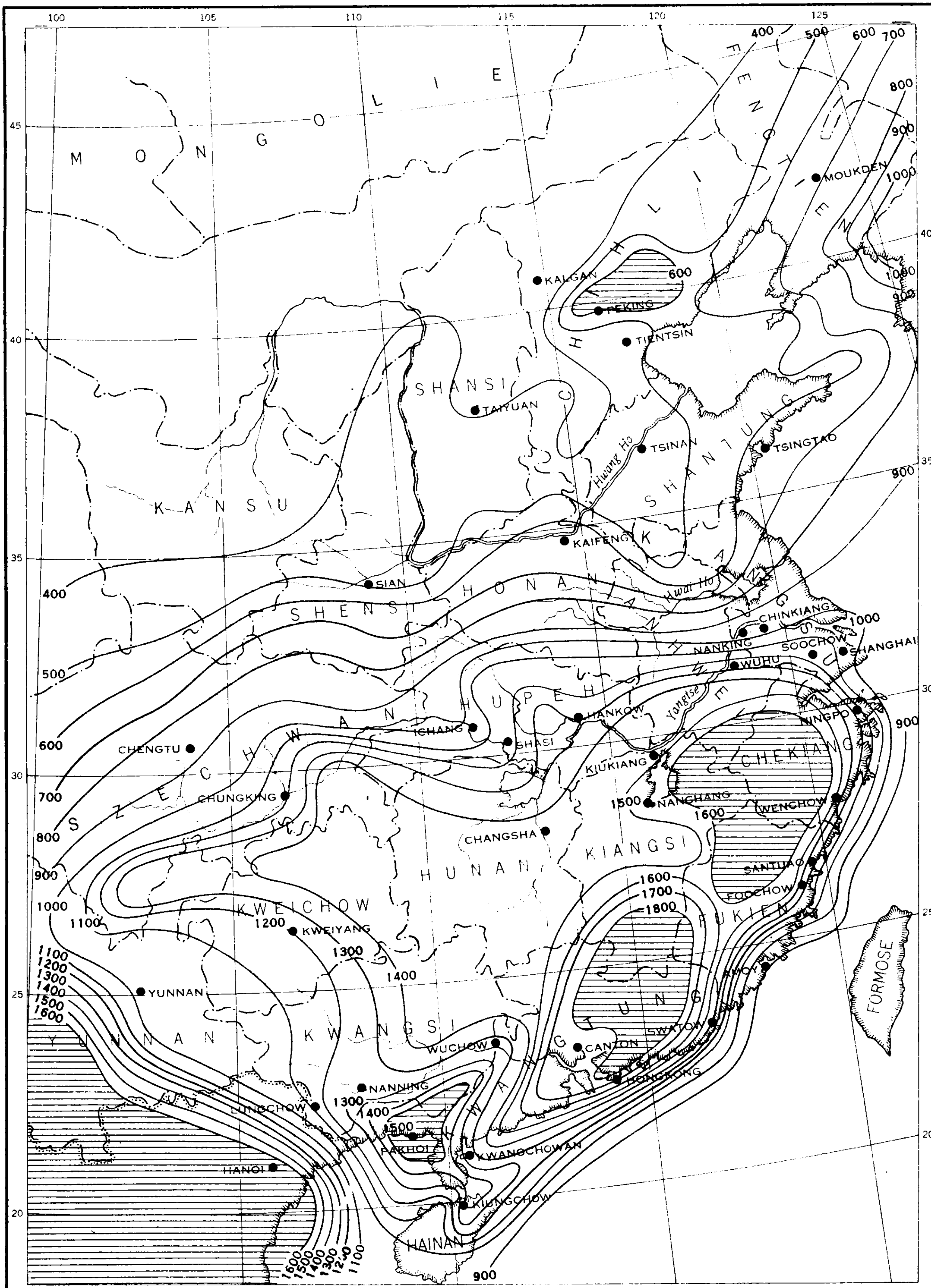
TABLE 2.—*Number of typhoons that reached land or traversed the provinces of east China in 31 years (1893–1924)*

	Kwantung	Fukien	Chekiang	Kiangsu	Shantung	Liaotung	Total
April	1	0	0	0	0	0	1
May	5	1	2	0	0	0	8
June	7	1	2	1	0	0	11
July	28	13	7	11	6	7	72
August	26	16	14	22	8	6	92
September	24	15	9	7	2	1	58
October	10	1	1	2	0	0	14
November	2	4	0	0	0	0	6
December	1	0	0	0	0	0	1
Total	104	51	35	43	16	14	263
Average	3.3	1.6	1.1	1.3	0.5	0.4	8.5

of year the great winter anticyclone of Siberia encroaches upon the plains of Mongolia and Manchuria and these provinces as well as those of Chili, Shansi, Shensi and Kansu receive very little precipitation, most if not all of which is in the form of snow. Two areas in south China, the eastern one in Chekiang and northern in Fukien receive as much as 200 mm. (7.87 inches) the second area receiving an equal amount is found immediately to the west of the one just described and is in the provinces of Kiangsi and Hunan.

In spring the rainfall of north China increases quite rapidly, in fact it is more than double that of winter and this is also true of south China as well. In the south of

Chart XIV. A. J. H. Mean Annual Rainfall for China (mm.)



China there is a single area of as much as 600 mm. (23.62 inches) centered in and around the Province of Kiangsi whence the amounts shade off to 300 mm. on the coast and also in the Yangste Valley below Chunking.

In summer the maximum precipitation is reached in all China. An area of 500 mm. (19.68 inches) appears just west of the Gulf of Pechili and near to Peking. Three other areas of large precipitation appear in the south; the first is in the lower Yangste Valley, the second in Kwantung and on the coast from Canton to Pakhoi, while the third is just west of Yunnan in the Province of the same name. In autumn the rainfall decreases; north of the Yangste Valley it generally amounts to less than 200 mm. and in the far north many stations have less than 100 mm.

In the south the maximum of autumn reaches 400 mm. (15.75 inches) in parts of Chekiang and Kiangsi and also along the coast from Hong Kong to the Island of Hainan and finally there is a region of 300 mm. (11.81 inches) in western Yunnan.

Extremes of rainfall.—The absolute maximum yearly rainfall at any one station in China during the observational period was 3,962.9 mm. (156.02 inches) in 1923 at Pakhoi, on the Kwantung coast in north latitude 21 : 29. The author remarks that this is not extraordinary for the latitude of that station, and that the total as given for that station may easily be surpassed in northeast Formosa. At Kuling, central China, in north latitude 29 : 30 in 1911, a total of 3,381.7 mm. (120.61 inches) was recorded, of which 700.3 mm. (27.57 inches) fell in August and 628.4 mm. (24.741 inches) in September. Interior stations of the central plain of China have recorded as much as 1,788 mm. (70.39 inches) (Wuhu, 1911), and on the plains north of Peking a fall of 1,052.2 mm. (41.42 inches) in 1924 is of record. The minimum annual precipitation, as well as the maximum, is given in Table 3 for as many of the stations as have sufficiently long records to yield dependable data.

The maximum 24-hour rainfalls reach a total of as much as 540 mm. (21.26 inches) on the Kwantung coast and as much as 707 mm. (27.83 inches) was recorded on Victoria Peak, Hong Kong, on May 5, 1889, under the influence of a typhoon. In the interior remote from the coast the maximum 24-hour amounts are in the neighborhood of 300 mm. (11.81 inches).

These amounts agree fairly well with maximum 24-hour rainfalls in the United States.

RAINFALL VARIABILITY

The ratio of the greatest annual rainfall to the least annual gives a measure of the rain variability in China. That ratio is given in the final column on the right side of Table No. 1. In general it is somewhat larger in China than in the United States, the country with which this reviewer is best acquainted. Two cases were found in which the record for the year of minimum precipitation is evidently faulty, the first being for North Saddle, year 1887, with a total of but 86 mm. (3.38 inches) whereas the maximum for the same station was 1,566.3 mm. (61.66 inches) and the mean is 829 mm. (32.67 inches). The second case is that of Lungchow for 1902 with a total of 197.3 mm. (7.76 inches). The maximum for this station was 1,792.0 mm. (70.55 inches) and the mean is 1,269.3 mm. (50.30 inches). In Table 1 the reviewer has used the next higher minimum value.

In a country so large as China it is not to be expected that years of great deficiencies in rainfall will occur rather generally over an extended area but rather that the stations having great deficiencies of rainfall will have a local distribution being confined to parts of provinces and this expectation is fully confirmed by the published records in Father Gherzi's contribution. Dry years in China seem to occur in groups rather than in any one individual year, thus 1887, 1888, and 1889 were dry years in Shantung, 1894 and 1895 were dry along the coast of Kwantung and Kiangsu. There was also a series of dry years 1899–1903 with the greatest drought in 1902 in Hupeh, Szechewan Chihli, and Kwangsi. The year 1910 was a dry year in China as well as in the United States.

Mean annual distribution.—Figure 2 is a reproduction of Father Gherzi's map of annual precipitation. In commenting on this map he attributes the area of relatively large rainfall near Peking to orographic influences.

In south China, however, it is different; there are shown on the map by shading three areas of great rainfall, near the coast, one in Chekiang to the north of Fukien and Kiangsi, the other northeast of Kwantung and southeast of Kiangsi and the third around Pakhoi. The orographic influence does not seem to dominate in these cases, seeing that Kweichow where there are great mountain masses the quantity of rain received is well below that of the three zones above-mentioned. Since, however, rainfall stations in Kweichow are few the belief is expressed by the author that the mean annual isohyet of 1,500 mm. (59.05 inches) is reached in that Province.

The large rainfall in the three regions mentioned is clearly due to the effect of typhoons.

The cross-hatching in Figure 2 is not drawn strictly to scale since the idea of the author was simply to emphasize the fact that certain regions had a maximum of precipitation as compared with immediately adjacent areas.

The rainfall régime of a large part of China resembles rather closely that of the Great Plains States of North America, although the yearly maximum in the latter is reached a little earlier in the year than in China and of course, the typhoon effect whereby the yearly maximum in parts of China is reached in July, is absent from North America.

The wet years in some parts of China were 1889, 1903, 1905–06, 1911, 1914–15, and 1920–1924 but in some of these years there were places where the rainfall was deficient.

In other words the rainfall distribution in China does not differ materially from that in other parts of the world.

Failure of the summer rains and an absence of typhoons are the main causes of drought which is naturally more acute in the northern provinces than in the southern because of the smaller average precipitation in those provinces.

Lack of space prevents us from touching upon other interesting features in Father Gherzi's report.

I have grouped in Table 3 the records of the fundamental stations and have added a small number of the most valuable of the secondary stations as published in the original so as to give in a single table the records of the most representative rainfall stations in China. The table follows on next page.

TABLE 3.—*Monthly and annual mean precipitation, greatest and least annual and their ratio*

[The annual values have been rounded off to whole millimeters; monthly values in millimeters and tenths, Chinese stations]

Province and station	From	To	North latitude	East longitude	Elevation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual			Ratio
																		Mean	Max.	Min.	
			° ′	° ′	m.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	
Manchuria:																					
Antung	1907	1924	40 06	124 21	9	9.9	11.2	24.3	37.4	90.1	100.4	272.3	214.5	130.0	64.3	41.2	5.7	1,001	1,636	504	3.25
Hunchun	1914	1924	42 53	131 18	104	1.6	1.3	11.1	30.4	78.7	73.7	92.4	111.9	108.0	39.2	24.0	1.9	574	796	374	2.13
Kungchuling	1915	1924	43 31	124 48	203	5.3	3.3	10.7	17.5	53.1	87.5	172.8	144.4	67.5	38.7	13.4	3.8	618	841	392	2.15
Mukden	1906	1924	41 48	123 23	44	4.2	6.4	19.3	27.6	57.1	85.7	159.1	156.0	83.7	40.3	26.7	6.1	672	1,065	341	3.12
Newchwang	1902	1924	40 41	122 16	3	5.5	4.9	26.2	26.8	53.2	64.1	157.5	156.0	74.8	39.2	24.5	6.3	639	947	396	2.40
Harbin [1]	1898	1920	45 46	126 50	147	4.1	5.9	8.4	23.5	40.7	104.8	147.6	104.0	53.9	30.0	8.4	5.3	537	745	376	1.98
Chihli:																					
Chinwangtao	1908	1924	39 55	119 38	3	2.9	3.0	15.8	15.8	61.3	71.3	193.1	187.7	79.7	26.7	13.6	2.1	673	987	369	2.68
Peking [2]	1875	1908	39 57	116 28	38	5.5	3.7	9.2	21.7	21.3	73.2	263.8	151.6	60.1	19.3	7.2	0.8	637	1,084	351	3.09
Shuangyin	1919	1925	39 07	116 45	(?)	3.1	1.8	8.5	13.2	29.6	64.9	192.3	145.0	22.5	10.1	4.8	3.5	499	------	------	------
Tangku	1909	1924	39 00	117 37	4	4.7	2.7	9.2	11.4	28.4	74.2	164.8	151.3	42.2	16.6	11.0	1.9	518	905	238	3.80
Tientsin [1]	1891	1925	39 09	117 11	5	3.5	2.4	10.3	17.0	27.3	64.2	173.9	133.3	48.4	16.0	9.8	3.1	509	796	254	3.13
Tamingfu [1]	1908	1925 [3]	36 19	115 12	(?)	10.8	9.1	13.3	17.2	20.0	64.8	138.0	143.0	88.0	16.1	12.4	3.5	536	867	251	3.45
Yangliuching [1]	1919	1925	39 08	116 59	(?)	3.2	4.0	9.2	12.2	27.8	72.1	188.8	136.9	32.8	15.5	6.0	6.5	515	874	432	2.02
Shansi:																					
Sinchow [1]	1919	1925	38 28	112 45	(?)	1.6	2.1	11.5	18.5	28.2	45.2	155.1	108.4	35.1	11.9	3.7	1.2	422	501	365	1.37
Tatungfu [1]	1919	1925	40 07	113 13	(?)	0.9	4.9	7.3	16.5	35.9	46.3	111.3	92.3	30.7	22.5	2.3	0.2	371	------	------	------
Tienchin [1]	1921	1924 [3]	40 30	113 59	(?)	1.2	0.0	8.2	7.7	28.4	41.5	111.3	109.7	30.2	23.3	1.1	0.7	363	------	------	------
Luanfu [1]	1919	1925	36 05	113 03	(?)	6.9	8.0	11.7	29.9	35.8	61.0	188.8	81.6	45.2	19.2	2.7	6.9	497	675	------	------
Shensi: Tungyuenfong [1]	1921	1924	34 30	109 04	365	3.0	0.5	7.4	33.6	59.3	47.2	91.3	133.9	50.4	22.0	6.0	6.3	460	------	------	------
Shantung:																					
Chefoo	1886	1924	37 33	121 22	3	12.9	10.5	16.5	25.8	33.4	60.4	169.7	155.8	64.1	25.0	28.6	17.1	620	976	360	2.71
Howki	1880	1924	38 04	120 39	90	3.6	3.6	9.4	19.4	33.2	53.0	142.5	99.3	55.6	21.2	17.7	4.0	462	1,141	266	4.29
Northeast Promontory	1886	1924	37 24	121 42	54	8.6	6.7	14.5	32.7	33.8	67.2	137.8	126.9	69.5	27.8	26.6	14.6	567	900	219	4.11
Southeast Promontory	1886	1924	36 54	122 32	12	9.9	11.0	19.8	39.8	44.9	77.9	164.2	151.9	81.2	31.6	33.6	17.0	683	1,135	360	3.15
Tsingtao	1898	1924	36 04	120 19	77	10.6	9.8	20.2	38.0	41.1	85.0	155.5	147.0	83.5	33.2	20.6	16.0	660	1,273	353	3.60
Tsinanfu [1]	1916	1925	36 44	117 08	(?)	6.7	10.3	11.1	18.2	42.1	84.1	205.4	156.1	68.9	15.0	8.2	5.0	631	1,021	530	1.93
Szechewan:																					
Chungking	1891	1924	29 34	106 31	230	16.5	20.0	35.2	102.0	140.6	181.4	142.7	130.5	147.3	114.8	49.6	22.0	1,103	1,519	848	1.80
Tengyuech	1911	1924	24 45	98 14	1,633	11.1	28.7	48.4	69.7	122.2	247.8	294.1	282.8	159.8	158.6	36.3	19.2	1,479	1,793	1,154	1.55
Chengtu [1]	1907	1925	30 38	104 02	(?)	8.4	10.5	12.2	48.0	56.1	113.0	203.2	252.6	108.8	47.8	14.9	4.5	880	1,002	588	1.70
Honan:																					
Chengtefu [1]	1922	1925	36 04	114 20	(?)	5.5	7.9	10.2	25.8	29.1	41.7	193.3	132.7	44.1	14.7	1.5	1.9	508	924	------	------
Weihweifu [1]	1919	1925	35 22	114 03	(?)	7.1	6.2	8.7	33.0	33.2	51.0	216.7	99.5	40.3	12.5	1.8	1.5	512	647	------	------
Kaifeng [1]	1923	1926	34 43	114 24	(?)	7.0	13.4	16.2	19.1	27.2	53.4	270.5	118.7	66.1	25.8	5.8	8.0	631	881	------	------
Fukow [1]	1919	1925	34 09	114 30	(?)	14.2	17.1	11.9	32.0	58.4	90.4	225.1	117.4	62.0	20.9	16.4	12.4	678	------	------	------
Shanchow [1]	1918	1925	34 50	111 06	(?)	5.2	2.9	14.4	20.5	56.9	57.4	104.8	101.3	67.4	27.7	4.7	3.6	467	674	197	3.42
Hupeh:																					
Hankow	1880	1924	30 35	114 17	36	44.7	49.2	95.7	152.0	166.0	242.8	181.2	97.3	72.3	82.3	48.0	27.0	1,258	2,106	576	3.66
Ichang	1882	1924	30 42	111 16	518	19.5	29.1	53.6	100.6	122.6	154.8	210.8	169.5	100.4	84.0	35.8	14.1	1,095	1,493	644	2.32
Shasi [1]	1906	1920	30 18	112 15	51	31.4	42.1	86.7	127.8	133.9	176.0	203.4	161.6	86.9	94.7	64.2	19.1	1,228	1,610	829	1.94
Anhwei:																					
Tungcheng [1]	1912	1922	31 04	117 02	(?)	22.5	54.8	81.9	177.3	142.3	289.0	179.6	163.7	113.7	112.1	98.0	23.5	1,458	2,348	1,027	2.29
Nansuchow [1]	1917	[3] 1923	33 41	117 02	(?)	10.7	9.2	25.7	20.9	15.7	48.1	118.5	121.0	69.0	20.5	24.4	16.2	500	718	144	4.99
Hwokiu [1]	1906	1911	32 22	116 15	(?)	52.6	19.4	81.5	59.0	51.1	260.0	189.3	144.9	82.4	60.8	49.3	13.6	1,064	1,503	878	1.71
Wuhu	1880	1924	31 20	118 21	15	54.4	58.0	104.1	130.1	125.7	211.7	164.2	121.1	83.4	75.8	56.1	34.0	1,219	1,788	580	3.08
Kiangsu:																					
Chinkiang	1886	1924	32 13	119 25	12	40.4	44.2	74.7	92.0	90.7	177.7	185.9	122.3	97.5	47.8	41.2	25.2	1,040	1,583	552	2.87
Gutzlaff	1886	1924	30 49	122 10	75	47.0	60.0	94.1	96.9	84.1	141.2	90.4	66.9	100.3	73.7	46.5	35.8	937	1,337	565	2.37
Lukiapang	1908	1924	31 19	121 02	5	37.4	55.9	84.6	91.4	80.3	229.2	145.0	112.5	117.0	66.5	54.8	39.7	1,114	1,455	878	1.66
Nanking	1905	1924	32 05	118 49	16	41.1	50.2	75.1	101.0	81.9	182.7	207.0	115.7	93.6	49.7	41.2	29.8	1,069	1,621	576	2.81
Nantung	1917	1924	31 57	120 55	110	22.5	42.3	66.1	70.8	67.8	176.9	174.4	156.1	134.6	21.9	36.1	32.0	1,002	1,391	631	2.21
North Saddle	1886	1924	30 52	122 40	72	34.3	47.9	74.0	84.3	86.4	134.8	75.6	64.0	82.9	66.7	45.1	33.0	829	1,566	520	3.01
Shaweishan	1886	1924	31 25	122 14	53	42.3	51.5	80.1	85.6	85.8	151.1	102.3	105.7	112.4	74.0	47.1	28.9	967	1,335	624	2.14
Steep Island	1886	1924	30 13	122 35	63	43.5	54.2	89.2	98.0	96.6	155.4	66.3	55.3	78.3	69.4	41.4	27.8	875	1,338	633	2.11
Woosung	1904	1924	31 23	121 29	3	35.0	49.8	72.9	79.2	76.6	187.0	134.8	111.8	111.7	60.6	51.9	31.4	1,006	1,298	781	1.66
Zi-ka-wei	1873	1924	31 12	121 26	7	49.8	59.6	87.4	93.9	92.0	187.6	149.7	144.1	120.3	79.2	51.0	33.3	1,148	1,588	709	2.24
Chekiang:																					
Ningpo	1886	1924	29 57	121 45	10	68.3	88.1	109.9	118.2	112.0	190.1	126.0	176.5	177.4	109.1	62.9	47.9	1,386	2,135	912	2.34
Peiyushan	1904	1924	28 53	122 16	82	42.4	90.2	106.6	113.2	122.1	157.5	67.3	109.2	171.7	73.5	53.3	55.8	1,163	1,669	835	2.00
Wenchow	1883	1924	28 01	120 40	3	46.6	93.8	122.7	153.0	179.9	264.8	198.5	234.8	204.2	93.5	57.2	40.4	1,689	2,919	1,136	2.57
Hangchow [1]	1904	1919	30 11	120 12	10	61.7	84.8	136.6	146.3	110.5	248.7	151.6	176.0	134.6	107.3	82.2	60.3	1,501	1,836	1,212	1.51
Kweichow: Kweiyang [1]	1923	1926	26 18	106 40	1,075	29.5	22.5	27.8	85.1	165.7	164.5	247.9	87.6	164.5	113.4	45.1	15.4	1,169	------	------	------
Hunan:																					
Changsha	1909	1924	28 12	112 47	60	45.0	96.2	145.8	154.8	198.8	221.8	121.1	131.7	85.1	89.2	78.9	44.0	1,412	2,019	939	2.15
Yochow	1909	1924	29 24	113 10	(?)	32.4	73.1	143.2	153.3	152.2	223.8	115.4	115.2	73.7	96.6	109.5	34.1	1,322	1,691	912	1.85
Kiangsi:																					
Kiukiang	1885	1924	29 45	116 08	20	62.5	82.7	150.9	181.2	173.9	242.7	143.4	131.4	88.6	97.0	68.1	43.3	1,466	2,064	765	2.70
Kuling [1]	1909	1912	29 30	116 04	1,070	51.6	69.3	173.8	164.7	195.8	361.1	256.2	320.7	190.3	122.4	108.3	58.6	2,073	3,382	1,133	2.98
Fukien:																					
Amoy	1880	1924	24 27	118 05	4	32.4	77.3	89.0	125.7	157.6	177.4	133.2	167.7	109.5	49.3	31.6	31.8	1,182	1,638	654	2.50
Chapel Island	1880	1924	24 10	118 30	55	30.6	60.4	86.6	114.5	134.6	145.0	106.1	115.9	95.1	49.7	32.3	29.4	1,000	1,609	517	3.11
Foochow	1880	1924	25 59	119 27	20	47.0	96.3	115.0	121.8	149.7	208.1	161.0	182.0	214.3	50.9	41.4	47.2	1,435	2,730	896	3.05
Middle Dog	1892	1924	25 58	119 59	59	44.1	95.8	117.7	127.8	157.3	190.6	114.8	91.1	149.8	71.6	46.1	39.5	1,246	1,883	725	2.60
Ockseu	1886	1924	25 00	119 27	63	29.4	58.1	88.7	97.5	138.2	168.5	78.5	91.0	75.9	32.8	21.3	24.5	904	1,438	432	3.33
Santuao	1917	1924	26 45	119 45	4	44.2	91.6	125.5	146.5	208.2	281.3	170.4	194.6	225.1	91.0	43.9	59.9	1,688	2,219	1,067	2.08
Tungyung	1905	1924	26 22	120 30	111	24.9	76.6	82.4	83.9	135.6	119.5	61.3	69.0	91.2	4.73	25.9	21.6	839	1,605	406	3.95
Turnabout	1885	1924	25 26	119 56	65	38.9	78.1	105.0	117.7	160.4	185.2	86.5	106.7	100.7	54.7	40.5	42.6	1,117	1,830	572	3.20
Yunnan:																					
Mengtsz [1]	1906	[3] 1925	23 23	103 24	1,305	9.0	13.7	26.6	42.5	103.1	129.1	179.2	191.2	105.9	54.6	56.4	13.5	925	1,160	666	1.74
Yunnanfu [1]	1902	[3] 1925	25 02	102 41	1,893	13.4	12.9	13.7	18.3	93.6	154.8	238.8	206.6	136.3	92.3	44.2	15.4	1,040	1,451	844	1.72
Kwangsi:																					
Kiungchow	1912	1924	20 01	110 16	10	25.2	26.0	72.2	94.1	174.6	209.8	247.2	207.2	258.2	190.6	83.1	59.0	1,647	1,829	1,500	1.22
Lungchow	1896	1924	22 22	106 45	(?)	19.2	27.0	47.7	84.6	171.4	216.0	222.7	231.4	133.3	53.6	40.8	21.6	1,269	1,792	551	3.25
Wuchow	1898	1924	23 29	111 20	2	30.3	49.0	86.7	171.0	202.6	196.3	166.9	178.8	98.9	35.9	43.9	38.2	1,298	1,734	925	1.87
Kweilin [1]	1916	1926	25 19	110 20	(4)	37.6	96.3	128.7	242.3	357.6	391.0	180.6	186.5	88.3	84.3	51.5	40.8	1,986	2,469	1,309	1.76
Kweishien [1]	1918	1926	22 53	109 34	(4)	34.9	87.6	84.1	136.8	280.5	301.7	228.0	257.2	124.8	45.6	48.5	36.9	1,667	1,952	1,202	1.62
Nanning [1]	1921	1926	22 40	108 03	(4)	38.4	61.5	58.9	102.2	149.6	298.3	263.7	266.7	166.3	96.9	22.9	39.0	1,564	1,971	1,177	1.67
Nanyung [1]	1919	1926	25 16	114 04	(4)	53.8	125.7	152.8	229.4	245.5	271.3	99.7	204.4	83.6	80.6	34.3	34.4	1,616	1,882	1,168	1.61
Poseh [1]	1916	1926	23 52	105 57	(4)	19.3	30.3	36.2	74.7	178.7	216.4	270.8	225.4	132.4	44.2	41.5	16.1	1,286	1,660	949	1.75
Sanli [1]	1918	1926	23 31	109 38	(4)	61.3	88.6	56.1	102.3	221.5	282.9	182.3	228.5	124.4	51.8	84.2	48.5	1,532	------	------	------
Shanglin [1]	1918	[3] 1926	23 28	108 24	(4)	58.0	129.5	99.8	144.0	244.2	336.6	306.0	331.3	168.4	56.9	61.5	55.2	1,986	2,718	1,480	1.84
Sheklung [1]	1920	1926	23 05	113 59	(4)	41.1	108.7	109.7	179.5	256.6	252.1	272.0	302.4	139.8	39.5	59.5	14.8	1,776	------	------	------

[1] Secondary station. [2] Station of Russian Legation. [3] Broken record. [4] Not known accurately.

TABLE 3.—*Monthly and annual mean precipitation, greatest and least annual and their ratio*—Continued

[The annual values have been rounded off to whole millimeters; monthly values in millimeters and tenths, Chinese stations]

Province and station	From	To	North latitude	East longitude	Elevation	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual			Ratio
																		Mean	Max.	Min.	
			° ′	° ′	m.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	
Kwangsi—Continued.																					
Silung [1]	1916	1926	24 27	105 30	(4)	13.9	23.0	40.3	58.8	170.5	286.8	264.0	290.8	156.7	70.4	48.3	21.7	1,445	------	------	------
Souyen [1]	1916	1926	24 19	110 18	(4)	34.7	68.6	94.1	145.9	234.5	250.2	156.4	199.7	84.8	40.5	49.5	36.1	1,395	------	------	------
Sunchow [1]	1918	1926	23 17	109 59	(4)	65.9	122.8	97.9	203.9	323.5	397.2	243.6	259.8	132.2	60.0	80.0	65.5	2,052	2,249	1,641	1.31
Szengenfu [1]	1918	1926	23 22	108 02	(4)	51.5	87.0	67.0	135.4	188.5	294.0	287.2	328.9	154.4	49.0	59.3	44.0	1,746	------	------	------
Yungfu [1]	------	------	25 01	109 59	(4)	50.8	126.6	125.0	215.0	416.3	456.5	203.6	235.3	100.7	94.3	62.9	47.3	2,134	------	------	------
Kwantung:																					
Breaker Point	1892	1924	22 56	116 30	17	27.9	47.2	57.1	109.9	201.0	286.8	210.7	270.9	169.2	99.4	37.4	31.5	1,549	2,190	715	3.06
Canton	1907	1924	23 07	113 16	15	49.6	75.0	75.7	148.5	254.2	264.7	271.3	282.5	134.6	63.2	44.4	35.5	1,699	2,796	1,102	2.54
Chilang Point	1911	1924	22 40	115 40	28	21.8	58.2	61.4	94.6	181.3	258.4	232.4	240.9	140.5	48.0	34.5	29.1	1,401	1,985	989	2.01
Lamocks	1892	1924	23 16	117 17	58	28.1	36.9	55.6	99.3	124.7	177.7	166.3	164.8	139.3	85.3	26.7	23.4	1,128	1,834	545	3.37
Macao	1910	1924	22 12	113 32	20(?)	22.1	51.0	64.7	121.8	307.7	338.6	235.7	253.0	172.9	112.6	54.7	26.4	1,761	2,375	1,305	1.82
Pakhoi	1885	1924	21 29	109 07	5	32.0	33.1	76.0	107.2	171.1	292.8	503.0	506.6	272.5	81.2	45.4	48.4	2,169	3,962	1,389	2.85
Hong Kong	1884	1924	22 18	114 10	32	32.7	44.5	68.0	134.9	304.2	402.5	356.0	371.9	247.0	130.1	43.2	27.3	2,162	3,041	1,164	2.67
Samshui	1900	1924	23 06	112 53	10	41.8	65.5	112.3	184.3	305.0	267.7	243.5	260.7	143.4	69.5	47.6	45.9	1,787	2,401	1,044	2.30
Swatow	1880	1924	23 23	116 40	4	35.3	62.5	79.9	143.5	229.5	266.6	197.8	212.2	138.5	73.0	39.4	38.1	1,516	2,512	670	3.75
Kwangchowwan [1]	1913	1925	21 05	108 10	14	15.7	28.6	42.8	76.6	171.2	214.5	220.4	310.5	185.5	59.7	52.7	28.7	1,407	1,715	1,133	1.51
Liuchow [1]	1921	1926	24 53	112 57	(4)	40.1	105.1	131.4	195.7	309.6	250.8	148.3	129.3	58.4	86.9	42.8	27.1	1,526	------	------	------
Nanyung [1]	1919	1926	25 16	114 04	(4)	53.8	125.7	152.8	229.4	245.5	271.3	99.7	204.4	83.6	80.6	34.3	34.4	1,616	------	------	------
Sheklung [1]	1920	1926	23 05	113 59	(4)	41.1	108.7	109.7	179.5	256.6	252.1	272.0	302.4	139.8	39.5	59.5	14.8	1,776	------	------	------
Shiuchow [1]	1919	1926	24 55	113 08	(4)	38.1	119.7	123.7	202.3	271.0	267.7	84.1	170.5	73.8	62.0	23.8	33.5	1,470	------	------	------
Yintuk [1]	1919	1926	24 10	113 19	(4)	47.8	120.1	133.5	278.3	314.5	340.6	148.7	248.2	92.8	60.9	30.0	27.9	1,843	2,553	1,482	1.72
Hainan (Island):																					
Kiungchow	1912	1924	20 01	110 16	10	25.2	26.0	72.2	94.1	174.6	209.8	247.2	207.2	258.2	190.6	83.1	59.0	1,647	1,829	1,500	1.22
Lamko	1912	1924	20 00	109 42	15	16.1	17.7	39.1	55.5	83.5	129.1	200.8	211.3	194.3	125.7	50.0	27.2	1,150	1,518	707	2.15

[1] Seconday station. [4] Not known accurately.

RAPID DECREASE IN BAROMETRIC PRESSURE NORTHWEST OF STORM TRACK ON NOVEMBER 17, 1928

551.54 (77)

By W. S. BELDEN

[Weather Bureau, St. Joseph, Mo.]

A rapid decrease in barometric pressure occurred in southeastern Kansas, northwestern Missouri, and south-central Iowa on the morning of November 17, 1928, in connection with the northeastward movement of a cyclonic area that was central near Columbia, Mo., at 7 a. m., ninetieth meridian time, on that date.

The fall in pressure at St. Joseph, Mo., was 0.25 inch in 40 minutes, from 4:50 a. m. to 5:30 a. m., as shown in Figure 1. Similar though slightly less pronounced falls were registered at Wichita and Iola, Kans., Kansas City, Mo., and Des Moines, Iowa. The time of the earliest abrupt fall was 1:30 a. m. at Wichita. Then followed in order rapid falls at stations to the northeastward, Des Moines being reached at 8:30 a. m.

Although St. Joseph was approximately 150 miles northwest of the storm track, its lowest pressure, reduced to sea level, was lower than any other sea-level pressure reported in the cyclonic area west of the Mississippi River. See accompanying table of data.

In or near and to the south of the storm track recorded pressure falls were generally gradual. The greatest in two hours ranged from 0.06 to 0.13 inch, except at Columbia and Springfield, Mo., where the sharpest decreases, amounting to 0.10 inch in each case, came within about one hour, and at the apparent time of the nearest approach of the storm center. In Nebraska and western and north-central Kansas pressure changes attending the passage of the storm were not unusual.

The decided pressure decreases were each accompanied by northerly surface winds, the highest velocity being 32 miles an hour from the northeast at Wichita.

Excessive rainfall, mostly in the northeast quadrant of the cyclone, occurred over a belt approximately 100 miles wide extending from northcentral Oklahoma northeastward to southeastern Iowa. Thunderstorms were general in Oklahoma, Kansas, Missouri, and Iowa on the 16th but the only stations reporting thunderstorms on the 17th were Wichita and Kansas City.

Temperatures were much above normal in Missouri and adjacent States on the 16th, and in the central, southern, and eastern portions of Missouri on the morning of the 17th, when the temperature ranged from 40° at St. Joseph to 60° at St. Louis.

The lowest observed sea level pressure readings appear on Figure 2. Isobars show that over most of Missouri and southeastern Iowa the minimum pressure was less than 29.60 inches, with three centers of low pressure.

Hour lines indicating the progressive movement of the abrupt falls in pressure appear on Figure 3. The lines for 9 a. m., 10 a. m., and 11 a. m. have been drawn not for the lowest readings, but for slight sharp falls, which seem to be directly associated with the more abrupt falls. The lowest pressure readings at Hannibal, Keokuk, Davenport, and Dubuque were in each case registered later than the slight sharp falls. At Oklahoma City the lowest barometer reading occurred at 5 p. m. November 16, the time of the nearest approach of the center of the storm area, but after the barometer had risen gradually for more than four hours, a fall of 0.08 inch was registered within 30 minutes ending at 10:10 p. m. This slight sharp fall also seems to be associated with the more abrupt falls, thus giving a basis for beginning the hour lines at 10 p. m. November 16.

A secondary atmospheric whirl of much intensity but somewhat limited diameter appears to have developed aloft over central Oklahoma about 10 p. m. November 16.